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Using BIOPLUME IV to Model Sustainability of MNA

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At most sites where Monitored Natural Attenuation (MNA) has been selected as a remedy for ground water contamination, dilution and dispersion are not the primary mechanisms responsible for attenuation along the flow path in the aquifer. In most aquifers, dilution and dispersion alone can not prevent the contaminants from impacting a receptor. Some additional process, such as biotic or abiotic degradation of the contaminant, is necessary to control risk and prevent exposure to receptors. At sites where this is the case, the sustainability of MNA is controlled by the supply of the limiting substrate required for degradation of the contaminants.

The computer application BIOPLUME IV has been rewritten to allow an evaluation of sustainability in those cases where the limiting substrate is an integral component of the aquifer matrix. Chlorinated solvents such as PCE or TCE can be destroyed by abiotic reactions with magnetite in the aquifer matrix. Fuel-derived contaminants such as benzene, MTBE, and TBA can be degraded by iron-reducing bacteria that consume iron (III) minerals in the aquifer matrix in the process of degrading the contaminant and associated organic materials. When the limiting substrate is used up in one portion of the aquifer, the contaminant can be expected to move with the flow of ground water until it enters a portion of the aquifer where the limiting substrate is still available. Over time, the region of the aquifer where the limiting substrate has been totally consumed will expand, and the footprint of the contaminant in the plume will expand with it.

Sustainability can be evaluated by comparing the total loading of contaminant (and associated materials that will also consume the limiting substrate) to the supply of the limiting substrate that is available to be consumed before a plume reaches a receptor.

At a chlorinated solvent spill site on the Twin Cities Army Ammunition Plant (TCAAP) north of St. Paul, Minnesota, PCE and TCE in a sandy water table aquifer are being consumed by an abiotic reaction with magnetite in the aquifer material. At a JP-4 jet fuel spill at the U.S. Coast Guard Support Center in Elizabeth City, North Carolina, MTBE is being naturally degraded under iron-reducing conditions in the aquifer. Microcosm studies at the R.S. Kerr Center suggest that iron reducing bacteria are responsible for anaerobic MTBE biodegradation at the site. The total loading of PCE and TCE at the TCAAP site was estimated by fitting a first order rate of attenuation over time to concentrations in the source area of the plume, and then integrating the area under the curve. The total loading of MTBE and BTEX compounds in the jet fuel spill was estimated from the MTBE and BTEX content of core samples. The supply of magnetite was estimated by analysis after magnetic separation. The supply of bioavailable iron (III) was estimated by a commercially available bioassay. BIOPLUME IV was used to simulate the length of the contaminant plumes at the time when the entire contaminant mass had been loaded to the aquifer.

This is an abstract of a proposed presentation and does not necessarily reflect EPA policy.